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(54) **Electric heater assembly**

(57) An electric heater assembly comprises at least one electric heater, each of which incorporates at least one sensing means (8) for use in detecting a cooking vessel (9) on a cooking plate (7) overlying the heater. The sensing means (8) is provided for the purpose of effecting selective energising and/or de-energising of one or more electric heating elements (3) in the or each heater. The or each sensing means (8) comprises an electrically conductive sensor loop. The or each sensor loop is connected to a circuit (100) comprising a non-oscillatory resonant circuit (102, 103), for the or each sensor loop, driven by an oscillatory circuit (101) such that the or each resonant circuit is operated at within ± 15 percent of its resonant frequency, the resonant circuit not forming part of the oscillatory circuit (101). A transformer (104, 105, 106), associated with the or each sensor loop (8), has a first winding (105) connected in the resonant circuit and a second winding (106) connected to, or integral with, its associated sensor loop (8). Means (110, 111) is provided to monitor change in a parameter associated with electric current in and voltage across the or each resonant circuit (102, 103) as a result of placement and/or removal of a cooking vessel (9) on and/or from the cooking plate (7) and to effect selective energising and/or de-energising of one or more electric heating elements (3) in the or each heater.

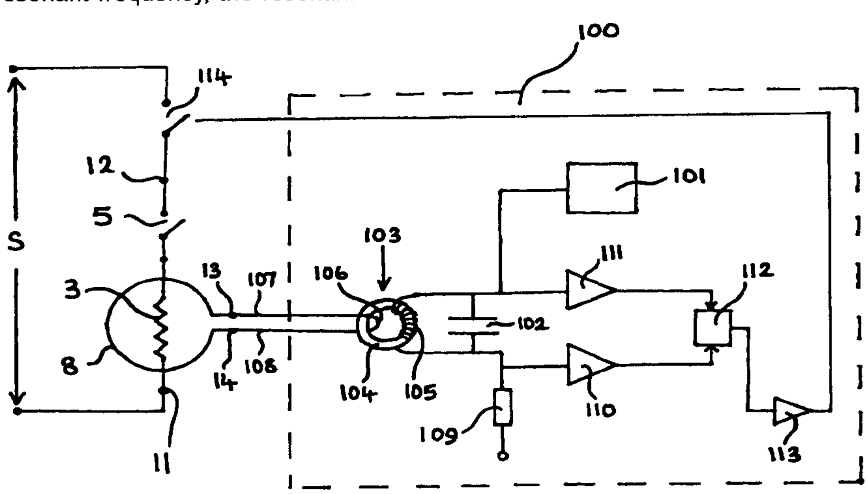

FIG. 4

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Description

[0001] This invention relates to an electric heater assembly in which an electric heater, such as of radiant form, incorporates sensing means for use in detecting a cooking vessel on a cooking plate, such as a glass-ceramic plate, overlying the heater. Such detection is used for the purpose of effecting selective energising and/or de-energising of one or more electric heating elements in the heater as a result of placement and/or removal of a cooking vessel on and/or from the cooking plate.

[0002] It is known to provide inductive sensing means in which a change of inductance upon placement or removal of a cooking vessel is evaluated by associated circuitry. An inductive sensor coil is connected to an oscillatory circuit and the change in inductance in the coil, as a result of placement or removal of the cooking vessel, is effective to produce a change in the frequency of oscillation of the oscillatory circuit. Attempts to directly monitor the change in frequency have not been very successful because such a change resulting from cooking vessel placement or removal may be small and may be of similar magnitude to changes, albeit of slower rate, resulting, for example, from changes in ambient temperature of the oscillatory circuit. This problem has been overcome by monitoring the rate of change of frequency, but has required relatively complex circuitry.

[0003] It is an object of the present invention to provide an electric heater assembly incorporating inductive sensing means for detecting placement and/or removal of a cooking vessel on and/or from a cooking plate and in which monitoring of a change of frequency, or rate of change of frequency, particularly of an oscillatory circuit, is not required.

[0004] According to the present invention there is provided an electric heater assembly comprising:

at least one electric heater, the or each heater incorporating at least one sensing means for use in detecting a cooking vessel on a cooking plate overlying the or each heater, for the purpose of effecting selective energising and/or de-energising of one or more electric heating elements in the or each heater, the or each sensing means comprising an electrically conductive sensor loop; and

circuit means for connection to the or each sensor loop and comprising:

a non-oscillatory resonant circuit, for the or each sensor loop, driven by an oscillatory circuit such that the or each resonant circuit is operated at within ± 15 percent of its resonant frequency, the resonant circuit not forming part of the oscillatory circuit;

a transformer, associated with the or each sensor loop, having a first winding connected in the resonant circuit and a second winding connected to, or integral with, its associated sensor loop; and

means to monitor change in a parameter associated with electric current in and voltage across the or each resonant circuit as a result of placement and/or removal of a cooking vessel on and/or from the cooking plate and effecting selective energising and/or de-energising of one or more electric heating elements in the or each heater.

[0005] The or each resonant circuit may comprise a parallel inductance-capacitance circuit in which an inductor is provided comprising the transformer.

[0006] The change in the parameter associated with the current and voltage may comprise change in phase difference between the current in and the voltage across the or each resonant circuit. The means to monitor the change in phase difference between the electric current and the voltage may comprise a voltage comparator, a current comparator, and a phase detector connected thereto.

[0007] The or each oscillatory circuit may be adapted to provide a sinusoidal output and may include means to provide voltage control of oscillation frequency.

[0008] A plurality of heating zones may be provided by a plurality of heaters having single heating zones and/or by at least one heater having plural heating zones, each heating zone being provided with at least one heating element and having an associated sensor coil and an associated resonant circuit. Multiplexing means may be provided, providing selective connection of the resonant circuits to a single oscillatory circuit and to a single means to monitor the change in the parameter associated with the current and the voltage for each resonant circuit whereby to effect energising and/or de-energising of the heating element or elements in appropriate heating zone or zones, according to placement and/or removal of a cooking vessel.

[0009] At least one temperature sensor may be provided, adapted and arranged to effect adjustment of oscillation frequency of the or each oscillatory circuit to compensate for temperature-induced drift in one or more parameters of one or more circuit components of the assembly.

[0010] A microprocessor-based control system may be provided for the assembly.

[0011] The or each transformer may have a toroidal core, which may be of ferrite material, on which the first and second windings are provided.

[0012] The second winding of the or each transformer may comprise only one turn or only a few turns.

[0013] The or each sensor loop may have only one

turn, or only a few turns, of electrical conductor which may be of wire or strip form.

[0014] The or each sensor loop may be provided substantially surrounding an associated heating zone of the or each heater and preferably screened from direct influence thereon of heat in the heating zone. The or each sensor loop may be provided in a recess or rebate in an upstanding insulating wall member of the or each heater or may be embedded in an upstanding insulating wall member of the or each heater. Any such recess or rebate may be at, or in the vicinity of, an upper surface (apex) of the upstanding insulating wall member of the or each heater.

[0015] The invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 is a plan view of one embodiment of an electric heater for use in the heater assembly of the present invention;

Figure 2 is a cross sectional view of the heater of Figure 1;

Figure 3 is a cross sectional view of part of an alternative arrangement of the sensor coil in the heater of Figure 1;

Figure 4 is a schematic circuit representation of an embodiment of a heater assembly of the present invention incorporating the heater of Figure 1;

Figure 5 is a plan view of a further embodiment of an electric heater for use in the heater assembly of the present invention;

Figure 6 is a cross sectional view of the heater of Figure 5;

Figure 7 is a schematic circuit representation of a further embodiment of a heater assembly of the present invention incorporating the heater of Figures 4 and 5;

Figure 8 is a plan view of a still further embodiment of an electric heater for use in the heater assembly of the present invention;

Figure 9 is a schematic circuit representation of a still further embodiment of a heater assembly of the present invention incorporating the heater of Figure 8; and

Figure 10 is a schematic circuit representation of an embodiment of a heater assembly of the present invention involving multiple heaters and multiplexer and microprocessor control means.

[0016] Referring to Figures 1 and 2, a radiant electric heater comprises a metal support dish 1 having therein a base layer 2 of thermal and electrical insulation material of well known form, and in particular of microporous thermal and electrical insulation material.

[0017] Supported on the insulation layer 2 to form a heating zone is an electrical heating element 3 of well known form and which, for example, could be of corrugated ribbon form, arranged on edge and secured by partial embedding in the insulation layer 2. Alternatively the heating element 3 could be of coiled wire or ribbon form, or lamp form, or metal foil form. Combinations of different forms of heating element could also be provided.

[0018] A terminal block 4 is provided on the edge of the dish 1 for electrically connecting the heating element 3 to an electrical voltage supply.

[0019] A well known form of temperature sensing or limiting device 5 is provided extending at least partly across the heater.

[0020] An upstanding peripheral wall 6 of thermal insulation material is arranged in the heater and may be separate from, or integral with, the base layer 2. The heater is arranged to be supported beneath a cooking surface 7, such as of glass-ceramic material, with the upper surface of the peripheral wall 6 in contact with the underside of the cooking surface 7.

[0021] An inductive sensor loop 8, for use in the detection of a cooking vessel 9 on the cooking surface 7, is provided in a recess in the upper surface of the peripheral wall 6 and surrounding the heating zone. The sensor loop 8 comprises a single turn of wire or metallic ribbon, or only a few turns (e.g. less than 5) of wire or ribbon, and has ends thereof electrically connected to terminals 13 and 14 in a terminal block 10 provided at the edge of the heater. The sensor loop 8 is shielded by the peripheral wall 6 from exposure to the heating element 3 and can comprise a material such as copper.

[0022] Instead of the sensor loop 8 being provided in a recess in the upper surface of the peripheral wall 6, as shown particularly in Figure 2, it may be provided in a rebate formed in the upper outwardly-directed corner of the peripheral wall 6, as shown by the detail in Figure 3.

[0023] An electric heater assembly is formed by connection of the heater of Figure 1 to an associated circuit means 100 for operation, as shown schematically in Figure 4. Connection of a voltage supply S to the heater is by way of terminal 11 on the terminal block 4 and terminal 12 on the temperature sensing or limiting device 5.

[0024] The circuit means 100 comprises an oscillatory circuit 101, providing a sinusoidal output adapted and arranged to oscillate at a substantially fixed predetermined frequency. Such oscillation frequency may be between 50 and 200 KHz and typically between about 100 and 120 KHz. The oscillator 101 is arranged to drive a non-oscillatory resonant circuit at the substan-

tially fixed predetermined frequency. The resonant circuit is a parallel L-C (inductance-capacitance) circuit, comprising a capacitor 102 and an inductor 103. The inductor comprises a transformer having a toroidal ferrite core 104 with a first, or primary, winding 105. The first winding 105 is connected in the resonant circuit and suitably comprises about forty turns of enamelled copper wire having a diameter of about 0.5 mm.

[0025] A second, or secondary, winding 106 on the core 104 comprises a single turn of thick wire, such as enamelled copper of about 1 mm^2 cross sectional area. The second winding 106 has two tail portions 107 and 108 which are kept as short as possible (preferably less than 0.5 metre in length) and arranged as close together as possible whilst being electrically insulated from each other. These tail portions 107, 108, are electrically connected to the terminals 13, 14 of the sensor loop 8 in the heater.

[0026] Alternatively, the second winding 106 with its tail portions 107, 108 could be provided integral with the sensor loop 8.

[0027] The resonant circuit is driven by the oscillatory circuit 101 such that it operates at within $\pm$ 15 percent of its resonant frequency. A shunt resistor 109 is included.

[0028] The electric current in the resonant circuit is monitored by a current comparator 110 and the voltage across the resonant circuit is monitored by a voltage comparator 111. The outputs from the comparators 110, 111 are fed to a phase detector 112 which monitors difference in phase between the electric current and the voltage. When the resonant circuit is at or near its resonant frequency there is little or no phase difference between the current and the voltage. However if a metal cooking vessel 9 (Figure 2) is placed on the cooking surface 7, the inductance of the transformer 103 changes. This results in a phase difference (if there was no difference previously), or a change in phase difference, between the current and voltage. The phase detector 112 detects this and provides an output signal to a comparator 113 as a result of which a relay switch 114 is caused to be closed, thereby causing the heating element 3 in the heater to be energised from the voltage supply S.

[0029] If the cooking vessel 9 is then removed from the cooking surface 7, this results in elimination of the phase difference, or a reduction of the change in phase difference, between the current in the resonant circuit and the voltage across the resonant circuit. This is detected by the phase detector 112 and the relay switch 114 is caused to be opened, resulting in de-energising of the heating element 3.

[0030] The transformer which serves as the inductor 103 is also advantageous in that it provides galvanic isolation between the sensor loop 8 and the associated electronic circuitry. Furthermore it matches the very low impedance of the sensor loop 8 to the associated electronic circuitry.

[0031] It should be noted that the resonant circuit 102, 103 does not form part of the oscillatory circuit 101, which drives the resonant circuit. Any placement or removal of a cooking vessel does not substantially affect the oscillation frequency of the oscillatory circuit 101.

[0032] Figures 5 and 6 show a radiant electric heater having two concentric heating zones and in which the inner zone is operated alone to heat a small cooking vessel, and the inner and outer zones are operated together to heat a large cooking vessel.

[0033] The heater comprises a metal support dish 21 having therein a base layer 22 of thermal and electrical insulation material, such as compacted microporous thermal and electrical insulation material of well known form.

[0034] A first electrical heating element 23, of similar form to that previously described with reference to Figures 1 and 2, is supported on the insulation layer 22, in a central region of the heater, to form a first heating zone 24.

[0035] The first heating zone 24 is arranged concentrically with a surrounding second heating zone 25 in which is located a second electrical heating element 26, supported on the insulation layer 22. The second electrical heating element 26 may be of the same form as, or of a different form to, the first electrical heating element 23.

[0036] A circular wall 27 of thermal insulation material is provided to define the first heating zone 24 occupied by the first heating element 23. The second heating zone 25, occupied by the second heating element 26, is defined by the wall 27 and a further circular wall 28 of thermal insulation material provided at the periphery of the heater. Instead of the walls 27, 28 being provided as separate individual items, they could be formed integrally with the base layer 22.

[0037] The heater is arranged to be supported beneath a cooking surface 29, suitably of glass-ceramic material, with the upper surfaces of the walls 27, 28 in contact with the underside of the cooking surface 29.

[0038] A terminal block 30 is provided on the edge of the dish 21 and has terminals 31, 32, 33 connected to the heating elements 23 and 26 and providing for external connection thereof.

[0039] A known form of temperature sensing or limiting device 34 extends at least partly across the heater and is arranged to de-energise the heater when a predetermined temperature is reached by the cooking surface 29.

[0040] A block 35 of thermal insulation material is arranged between the dividing wall 27 and the peripheral wall 28. The block 35 is shaped to form a tunnel through which the temperature sensing or limiting device 34 passes and also terminal tail portions of the first heating element 23 leading to the terminals 31 and 32 in the terminal block 30. The tunnel through the block 35 effectively forms an extension of the first heating

zone 24 and also thermally isolates the temperature sensing or limiting device 34 from the effects of the second heating element 26.

[0041] The heater is arranged such that the first heating element 23 is able to be energised alone by connecting terminals 31 and 32 of the heater to a voltage supply. Connection of terminal 32 to the voltage supply is effected through the temperature sensing or limiting device 34 by way of terminal 36 thereon.

[0042] Alternatively, the first and second heating elements 23 and 26 are able to be energised together in parallel by additionally connecting together terminals 31 and 33.

[0043] The first heating element 23 is arranged, when energised, to heat a first area 37 of the cooking surface 29 and the first and second heating elements 23 and 26 are arranged, when energised together, to heat a larger second area 38 of the cooking surface 29.

[0044] Accordingly, the first heating element 23 will be energised alone to heat a small metallic cooking vessel 39 placed on the cooking surface 29 and the first and second heating elements 23 and 26 will be energised together to heat a larger metallic cooking vessel 40 placed on the cooking surface 29.

[0045] In order to detect placement of a metallic cooking vessel 39 or 40 on the cooking surface 29 and to effect automatic energising of either the first heating element 23 alone, or the first and second heating elements 23, 26 together, according to the size of a cooking vessel 39 or 40 being placed, the following arrangement is provided.

[0046] A first inductive sensor loop 41, comprising a single turn, or only a few turns, of wire or metallic ribbon, is provided in a recess in the upper surface (apex) of the dividing wall 27 and thereby surrounding the first heating zone 24. Ends 42 of the first sensor loop 41 extend along grooves provided in the top of the thermal insulation block 35 and are electrically connected to terminals 43 and 44 on a terminal block 45 provided on the edge of the dish 21.

[0047] A second inductive sensor loop 46, similar to the first inductive sensor loop 41, is provided in a recess in the upper surface of the peripheral wall 28 and thereby surrounding the second heating zone 25. The ends of the second sensor loop 46 are electrically connected to terminals 47 and 48 on the terminal block 45 on the edge of the dish 21.

[0048] The first and second sensor loops 41 and 46 are shielded by the walls 27 and 28 from exposure to the first and second heating elements 23 and 26 and can comprise a material such as copper.

[0049] An electric heater assembly is formed by connection of the heater of Figure 5 to an associated circuit for operation, as shown schematically in Figure 7.

[0050] As shown in Figure 7, two circuit means 100 are provided, connected to the sensor loops 41 and 46. Each circuit means 100 is substantially the same as the corresponding circuit means 100 shown in Figure 4 and previously described in detail. Details of the construction and operation thereof will not therefore be repeated here with reference to Figure 7.

[0051] The resonant circuits in each of the circuit means 100 is driven by its oscillatory circuit such that it operates at within ± 15 percent of its resonant frequency as before. When each of the resonant circuits is at or near its resonant frequency there is little or no phase difference between the current and the voltage. However if a small metal cooking vessel 39 (Figure 6) is placed on the cooking surface 29 over the first heating zone 24, this is detected by the sensor loop 41 and results in a phase difference (if there was no difference previously), or a change in phase difference, between the current in and the voltage across the resonant circuit in the circuit means 100 connected to the sensor loop 41. This is detected by the phase detector in the circuit means and an output signal is passed by way of lead 115 to relay switch 116 to cause closure thereof and the heating element 23 in the heating zone 24 to be energised alone.

[0052] If the cooking vessel 39 is then removed from the cooking surface 29, this results in elimination of the phase difference, or a reduction of the change in phase difference, between the current and voltage of the resonant circuit connected to the sensor loop 41. This is detected by the associated phase detector and the relay switch 116 is caused to be opened, resulting in de-energising of the heating element 23.

[0053] If a larger metal cooking vessel 40 (Figure 6) is placed on the cooking surface 29 over both heating zones 24 and 25, this is detected by both sensor loops 41 and 46. The resulting changes in phase difference between the current and voltage for the resonant circuits connected thereto is detected. An output signal is passed by way of lead 115 to relay switch 116 to cause closure thereof and a further output signal is passed by way of lead 117 to relay switch 118 to cause closure thereof. Both heating elements 23 and 26 in the first and second heating zones 24 and 25 are thereby energised.

[0054] If the cooking vessel 40 is then removed from the cooking surface 29, a reverse change in phase difference between the voltage and current occurs for each of the resonant circuits connected to the sensor loops 41 and 46. This is detected by the phase detector in each of the circuit means 100, resulting in relay switches 116 and 118 being opened to deenergise the heater.

[0055] It is to be noted that when the small cooking vessel 39 is placed on the cooking surface 29 the sensor loop 46 is also influenced to some extent, the resulting change in phase difference between the voltage and current for the associated resonant circuit being insufficiently large for an output signal to be generated capable of causing relay switch 118 to be closed to cause energising of the second heating element 26.

[0056] Figure 8 shows a further radiant electric heater which, instead of having two concentric heating zones, as in Figure 5, has a circular heating zone 54

and a crescent shaped heating zone 55 separated by a wall 57, the wall 57 also extending around the periphery of the heater.

[0057] The circular heating zone 54 is provided with a heating element 53 and is operated alone to heat a small cooking vessel. The crescent shaped heating zone 55 is provided with a heating element 56 and is operated together with the circular heating zone 54 to heat a larger elongate or oval cooking vessel. The basic construction of the heater with regard to the materials involved therein such as a support dish 51, a base layer 52 of thermal and electrical insulation material, the wall 57, and the heating elements 53 and 56, is substantially the same as that of the heater shown in Figure 5 and will not therefore be described in detail again.

[0058] A terminal block 60 is provided on the edge of the dish 51 and has terminals 61, 62, 63 connected to the heating elements 53 and 56 and providing for external connection thereof.

[0059] A known form of temperature sensing or limiting device 64 extends across the circular heating zone 54 and is arranged to de-energise the heater when a predetermined temperature is reached by a cooking surface (not shown), such as of glass-ceramic, overlying the heater.

[0060] In operation of the heater, the heating element 53 in the circular heating zone 54 is able to be energised alone by connecting terminals 61 and 62 to a voltage supply. Connection of terminal 62 to the voltage supply is effected through the temperature sensing or limiting device 64 by way of the terminal 66 thereon.

[0061] Alternatively the heating element 56 in the crescent shaped heating zone 55 is able to be energised together with the heating element 53 in the circular heating zone 54 by additionally connecting together terminals 61 and 63.

[0062] In order to detect placement of a metallic cooking vessel on the cooking surface and to effect automatic energising of either the heating element 53 alone or the heating elements 53 and 56 together, according to the size of cooking vessel being placed, the following arrangement is provided.

[0063] A first inductive sensor loop 67, comprising a single turn, or only a few turns, of wire or metallic ribbon, is provided in a recess in the upper surface (apex) of the wall 57 and thereby surrounding the circular heating zone 54. Ends 68 of the first sensor loop 67 are electrically connected to terminals 69 and 70 on a terminal block 71 provided on the edge of the dish 51.

[0064] A second inductive sensor loop 72, similar to the first inductive sensor loop 67, is provided in a recess in the upper surface (apex) of the wall 57 and thereby surrounding the crescent shaped heating zone 55. The ends 73 of the second sensor loop 72 are electrically connected to terminals 74 and 75 on the terminal block 71 provided on the edge of the dish 51.

[0065] The first and second sensor loops 67 and 72 are shielded by the wall 57 from exposure to the heating elements 53 and 56 and can comprise a material such as copper.

[0066] An electric heater assembly is formed by connection of the heater of Figure 8 to an associated circuit for operation, as shown schematically in Figure 9. The construction of the assembly and the principles involved are substantially the same as those for the arrangement of Figure 7. A metal cooking vessel (not shown) located over the circular heating zone 54 will strongly influence the sensor loop 67 and hence its associated resonant circuit in the circuit means 100. The resulting change in phase difference between the current and voltage for the resonant circuit is detected and an output signal passed by way of lead 119 to a relay switch 120, causing the switch 120 to close and the circular heating element 53 to be energised. Removal of the cooking vessel causes a reversal of the change in phase difference to occur and relay switch 120 is opened, causing the heating element 53 to be de-energised.

[0067] If a larger cooking vessel (not shown) is located over both heating zones 54 and 55, both sensor loops 67 and 72 will be strongly influenced and hence so will be their associated resonant circuits in the two circuit means 100.

[0068] The resulting changes in phase difference between the current and voltage for both resonant circuits are detected. An output signal is passed by way of lead 119 to relay switch 120, causing the switch 120 to close and the circular heating element 53 to be energised. At the same time an output signal is passed by way of lead 121 to a relay switch 122, causing this switch to close and the crescent shaped heating element 56 to be energised in addition to the circular heating element 53. The reverse process takes place when the cooking vessel is removed, resulting in de-energising of both heating elements 53 and 56.

[0069] With this heater arrangement it must be ensured that the crescent shaped heating element 56 is not energised without the circular heating element 53. This is arranged by providing a double pole relay switch, represented by reference numerals 120 and 123.

[0070] Figure 10 shows a multiple heater assembly incorporating a muliplexer 124 and a microprocessor-based controller 125 and allowing a single oscillatory circuit 126 and a single means to monitor the change in phase difference between the current in and the voltage across a plurality of resonant circuits 102, 103 associated with corresponding sensor loops of a plurality of heaters and/or of a plurality of heating zones in a single heater. This multiple heater assembly is particularly appropriate for use with hob sets of heaters, allowing up to eight heating zones to be monitored and controlled according to placement and/or removal of cooking vessels.

[0071] Sensor loops 41, 46 of a heater of Figure 5 are each connected to associated resonant circuits 102, 103 which are connected to channels of the multiplexer

124.

[0072] Sensor loops 67, 72 of a heater of Figure 8 are likewise each connected to associated resonant circuits 102, 103 which are also connected to further channels of the multiplexer 124.

[0073] Sensor loops 8 of two heaters of Figure 1 are also each connected to associated resonant circuits 102, 103 which are also connected to still further channels of the multiplexer 124.

[0074] Two spare channels are provided on the multiplexer 124.

[0075] The oscillatory circuit 126 comprises a voltage controlled oscillator 127, providing a square wave output, and a square wave to sinusoidal wave converter 128 connected thereto to provide the necessary sinusoidal output. Voltage control of oscillation frequency of the oscillatory circuit is thereby provided.

[0076] Selective connection of the resonant circuits for each sensor loop is provided by the multiplexer 124 to the single oscillatory circuit 126 and the single means to monitor the change in phase difference between the current and voltage for each resonant circuit. The means to monitor the change in phase difference comprises a current comparator 129, a voltage comparator 130 and a phase detector 131.

[0077] As in Figure 4, a shunt resistor 109 is also provided.

[0078] In operation, a value is stored inside the microprocessor-based controller 125 corresponding to each required frequency of the voltage controlled oscillator 127 for each sensor loop 8, 41, 46, 67, 72. As each sensor loop is selected by the multiplexer, the microprocessor-based controller 125 monitors the magnitude of the phase difference between the current in, and the voltage across, each associated resonant circuit. The phase detector 131 has two analogue outputs. One output 132 represents the magnitude of the phase difference between the current and the voltage for the selected resonant circuit. The other output 133 provides directional information as to whether a cooking vessel is being placed on or removed from a heater and represents whether the current leads the voltage or the voltage leads the current.

[0079] Thus the microprocessor-based controller 125 is able to decide whether a cooking vessel has been placed or removed from the directional data.

[0080] When the assembly is powered up, the microprocessor-based controller 125 is arranged to automatically tune the resonant circuits with their associated sensor loops, by adjusting the voltage controlled oscillator 127, so that the current and voltage are substantially in phase for each resonant circuit. This automatically overcomes any initial problems associated with tolerances of components in the circuitry.

[0081] After a cooking vessel has been detected as having been placed or removed, the resonant circuits with their associated sensor loops are automatically retuned to bring the current and voltage for each circuit substantially back into phase, in preparation for the next step of detecting placement or removal of a cooking vessel, as the case may be. Output signals 134 from the microprocessor-based controller 125 are applied to control the energisation of the heating elements in the heaters by way of appropriate relays.

[0082] A further input 135 to the microprocessor-based controller 125 may be provided in the form of a temperature input, such as from an NTC thermistor. The thermistor allows the microprocessor-based controller 125 to adjust the oscillation frequency of the oscillatory circuit 126 to compensate for drift in parameters of components in the circuitry resulting from variations in ambient temperature.

Claims

1. An electric heater assembly comprising:

   at least one electric heater, the or each heater incorporating at least one sensing means (8) for use in detecting a cooking vessel (9, 39, 40) on a cooking plate (7, 29) overlying the or each heater, for the purpose of effecting selective energising and/or de-energising of one or more electric heating elements (3, 23, 26, 53, 56) in the or each heater, the or each sensing means comprising an electrically conductive sensor loop (8, 41, 46, 67, 72); and

   circuit means (100) for connection to the or each sensor loop (8, 41, 46, 67, 72) and comprising:

   a non-oscillatory resonant circuit (102, 103), for the or each sensor loop, driven by an oscillatory circuit (101, 126) such that the or each resonant circuit is operated at within ± 15 percent of its resonant frequency, the resonant circuit not forming part of the oscillatory circuit;

   a transformer (104, 105, 106), associated with the or each sensor loop, having a first winding (105) connected in the resonant circuit (102, 103) and a second winding (106) connected to, or integral with, its associated sensor loop; and

   means (110, 111; 129, 130) to monitor change in a parameter associated with electric current in and voltage across the or each resonant circuit (102, 103) as a result of placement and/or removal of a cooking vessel (9, 39, 40) on and/or from the cooking plate (7, 29) and effecting selective energising and/or de-energising of one or more electric heating elements (3, 23, 26,

53, 56) in the or each heater.

2. An electric heater assembly as claimed in claim 1, characterised in that in the or each resonant circuit (102, 103) comprises a parallel inductance-capacitance circuit in which an inductor (103) is provided comprising the transformer.

3. An electric heater assembly as claimed in claim 1 or 2, characterised in that the change in parameter associated with the current and the voltage comprises change in phase difference (112, 131) between the current in and the voltage across the or each resonant circuit (102, 103).

4. An electric heater assembly as claimed in claim 3, characterised in that the means to monitor the change in phase difference between the electric current and the voltage comprises a voltage comparator (111, 130), a current comparator (110, 129), and a phase detector (112, 131) connected thereto.

5. An electric heater assembly as claimed in any preceding claim, characterised in that the or each oscillatory circuit (101, 126) is adapted to provide a sinusoidal output, the or each oscillatory circuit preferably including means (127) to provide voltage control of oscillation frequency.

6. An electric heater assembly as claimed in any preceding claim, characterised in that a plurality of heating zones (24, 25, 54, 55) is provided by a plurality of heaters having single heating zones and/or by at least one heater having plural heating zones, each heating zone being provided with at least one heating element and having an associated sensor coil and an associated resonant circuit.

7. An electric heater assembly as claimed in claim 6, characterised in that multiplexing means (124) is provided, providing selective connection of the resonant circuits (102, 103) to a single oscillatory circuit (126) and to a single means to monitor the change in the parameter associated with the current and the voltage for each resonant circuit whereby to effect energising and/or de-energising of the heating element or elements in appropriate heating zone or zones, according to placement and/or removal of a cooking vessel (9, 39, 40).

8. An electric heater assembly as claimed in any preceding claim, characterised in that at least one temperature sensor (135) is provided, adapted and arranged to effect adjustment of oscillation frequency of the or each oscillatory circuit (126) to compensate for temperature-induced drift in one or more parameters of one or more circuit components of the assembly.

9. An electric heater assembly as claimed in any preceding claim, characterised in that a microprocessor-based control system (125) is provided.

10. An electric heater assembly as claimed in any preceding claim, characterised in that the or each transformer has a toroidal core (104), for example of ferrite material, on which the first and second windings (105, 106) are provided.

11. An electric heater assembly as claimed in any preceding claim, characterised in that the second winding (106) of the or each transformer (103) comprises only one turn or only a few turns.

12. An electric heater assembly as claimed in any preceding claim, characterised in that the or each sensor loop (8, 41, 46, 67, 72) has only one turn, or only a few turns, of electrical conductor, the turn or turns of electrical conductor preferably being of wire or strip form.

13. An electric heater assembly as claimed in any preceding claim, characterised in that the or each sensor loop (8, 41, 46, 67, 72) is provided substantially surrounding an associated heating zone of the or each heater, preferably screened from direct influence thereon of heat in the associated heating zone.

14. An electric heater assembly as claimed in claim 13, characterised in that the or each sensor loop (8, 41, 46, 67, 72) is provided in a recess or rebate in an upstanding insulating wall member (6, 27, 28, 57) of the or each heater.

15. An electric heater assembly as claimed in claim 14, characterised in that the recess or rebate is at, or in the vicinity of, an upper surface of the upstanding insulating wall member (6, 27, 28, 57) of the or each heater.

16. An electric heater assembly as claimed in claim 13, characterised in that the or each sensor loop (8, 41, 46, 67, 72) is embedded in an upstanding insulating wall member (6, 27, 28, 57) of the or each heater.

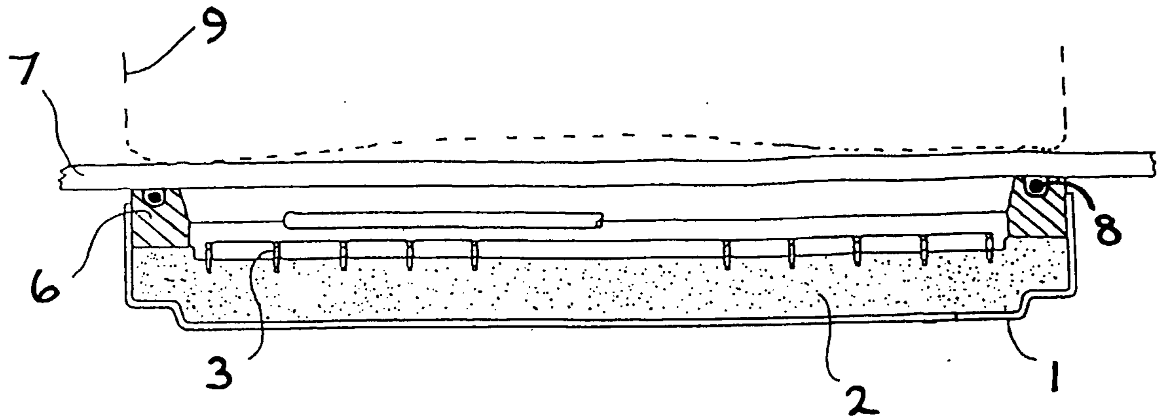


FIG. 2

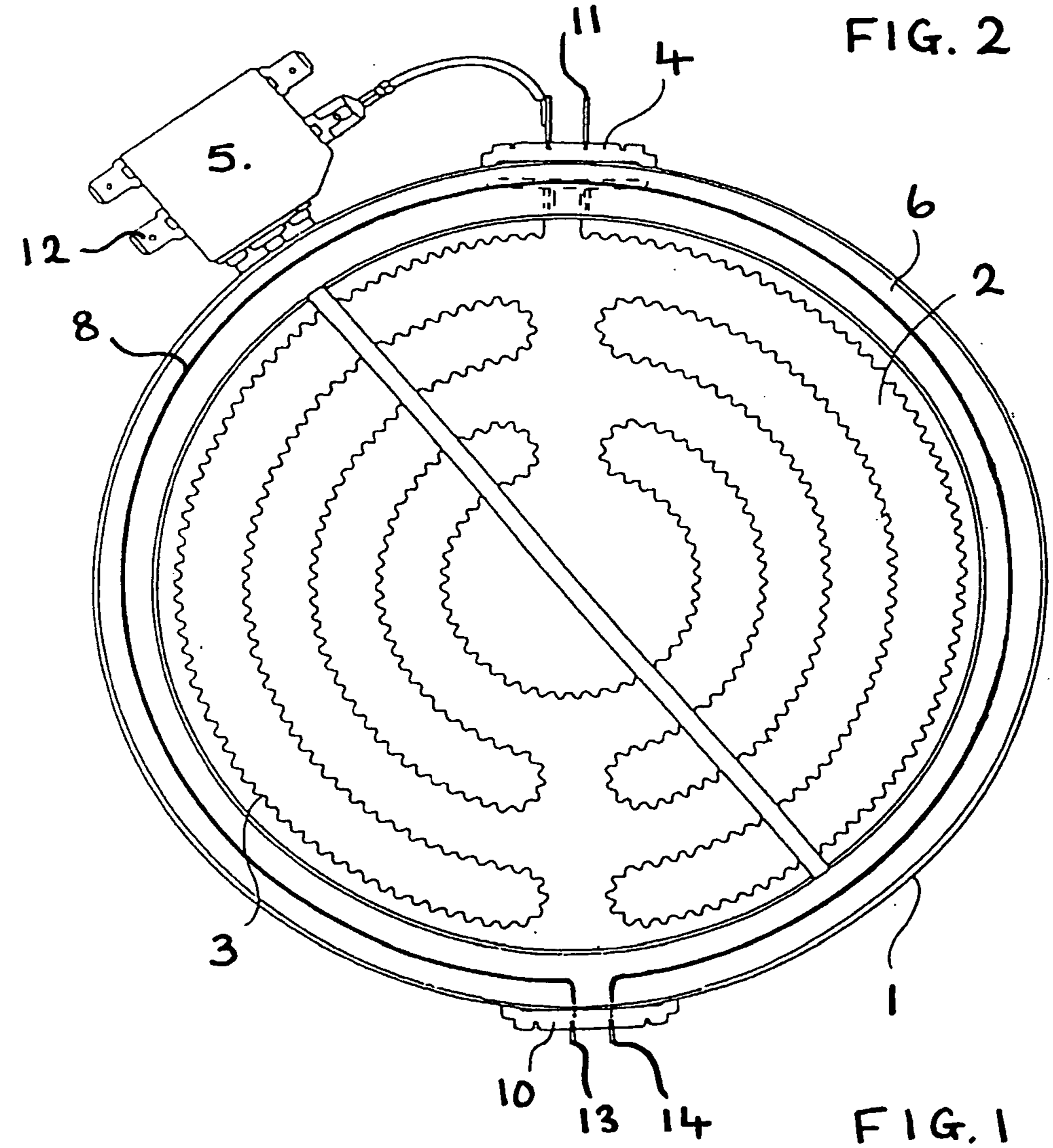


FIG. 1

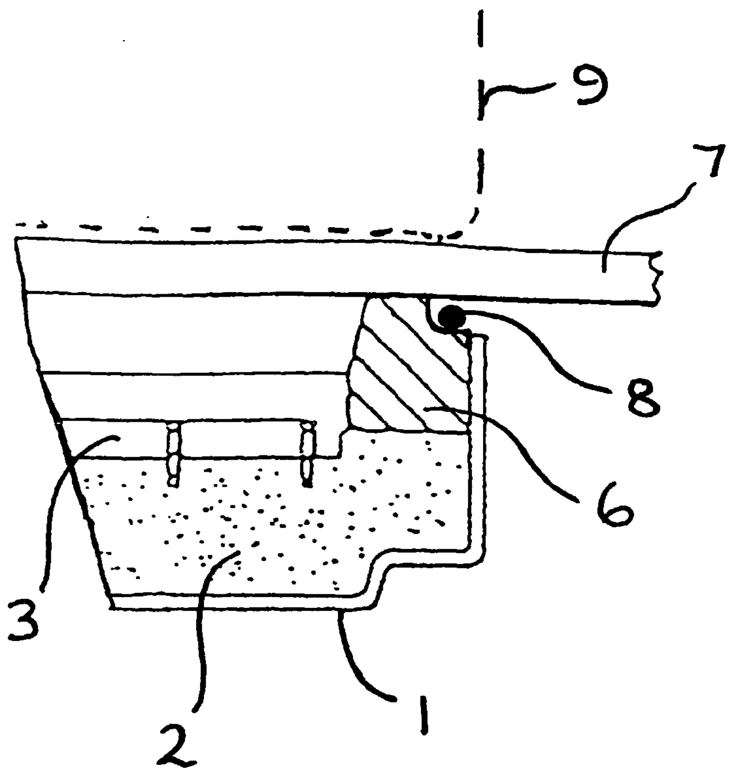
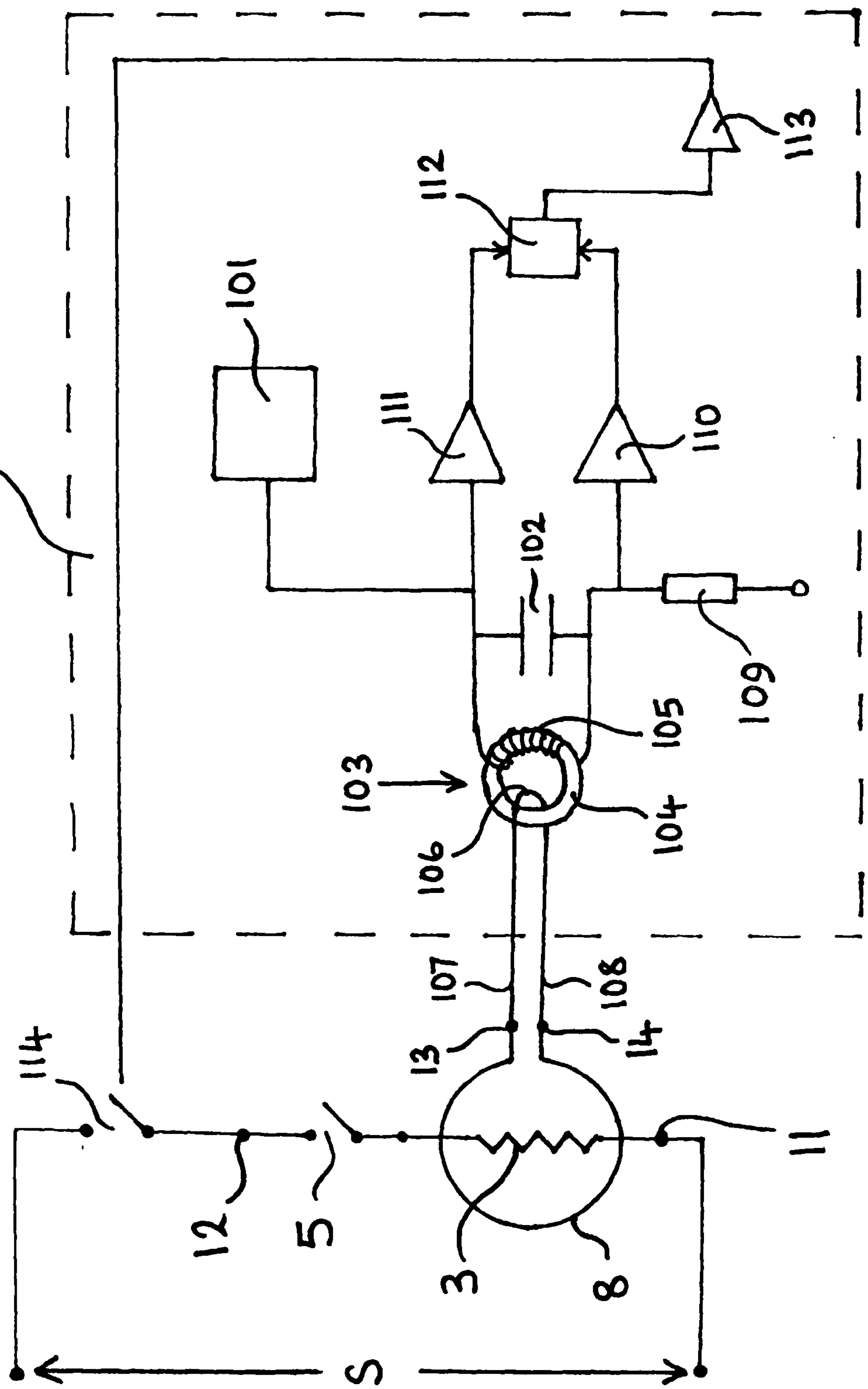


FIG. 3


100
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S

FIG. 4

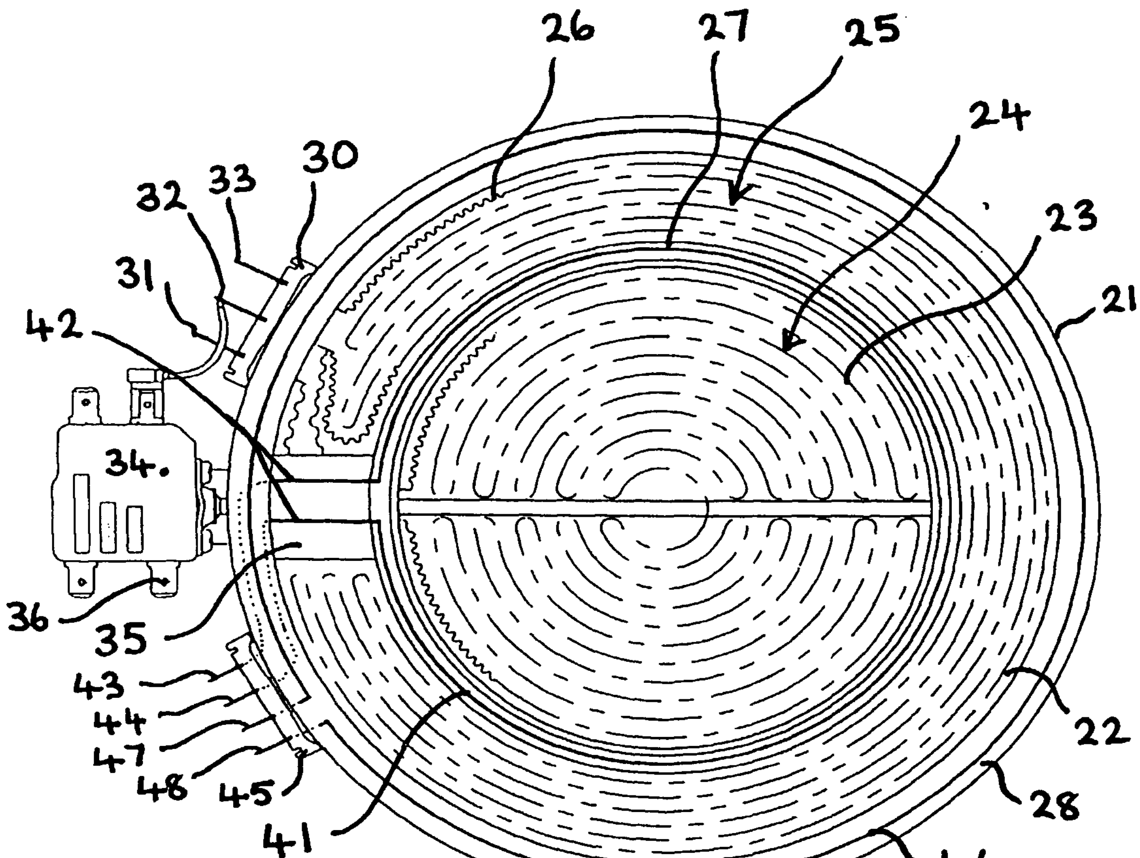
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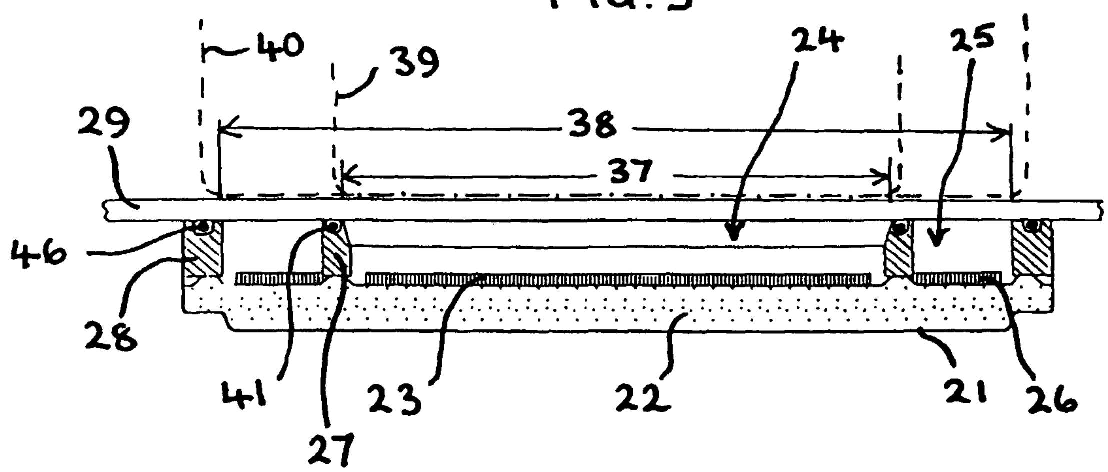
FIG. 5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39
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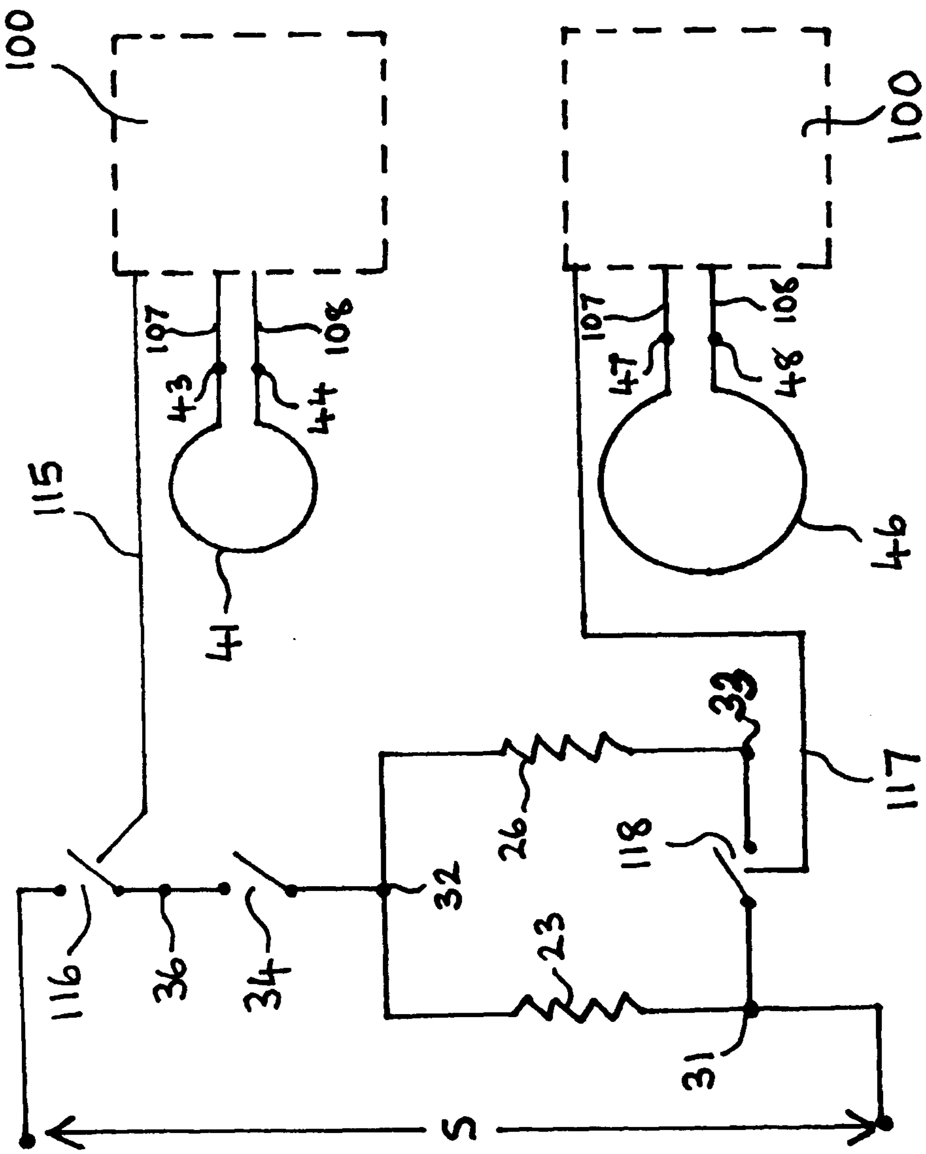
FIG. 6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44
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106
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116
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118
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117
31
5

FIG. 7

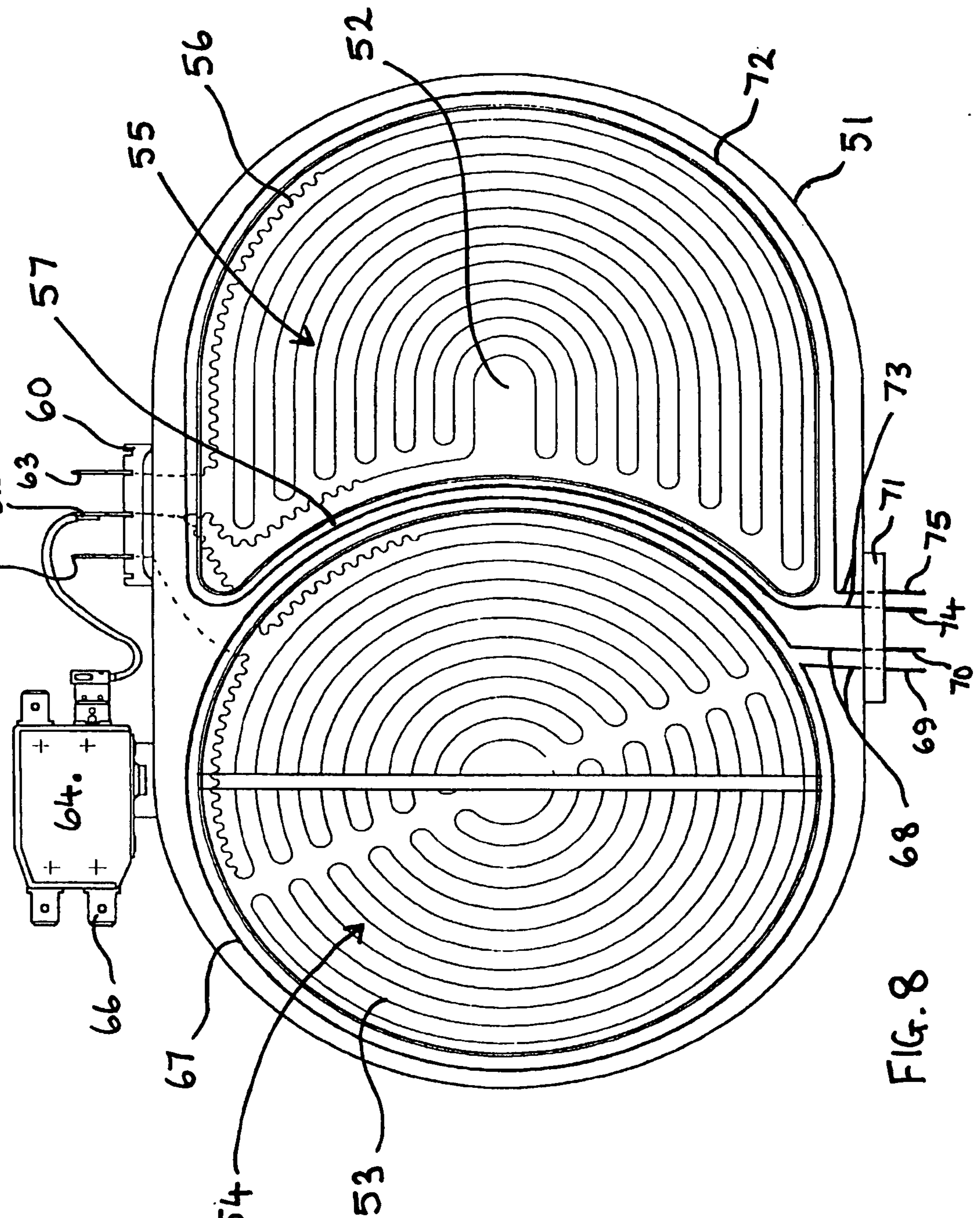

FIG. 8

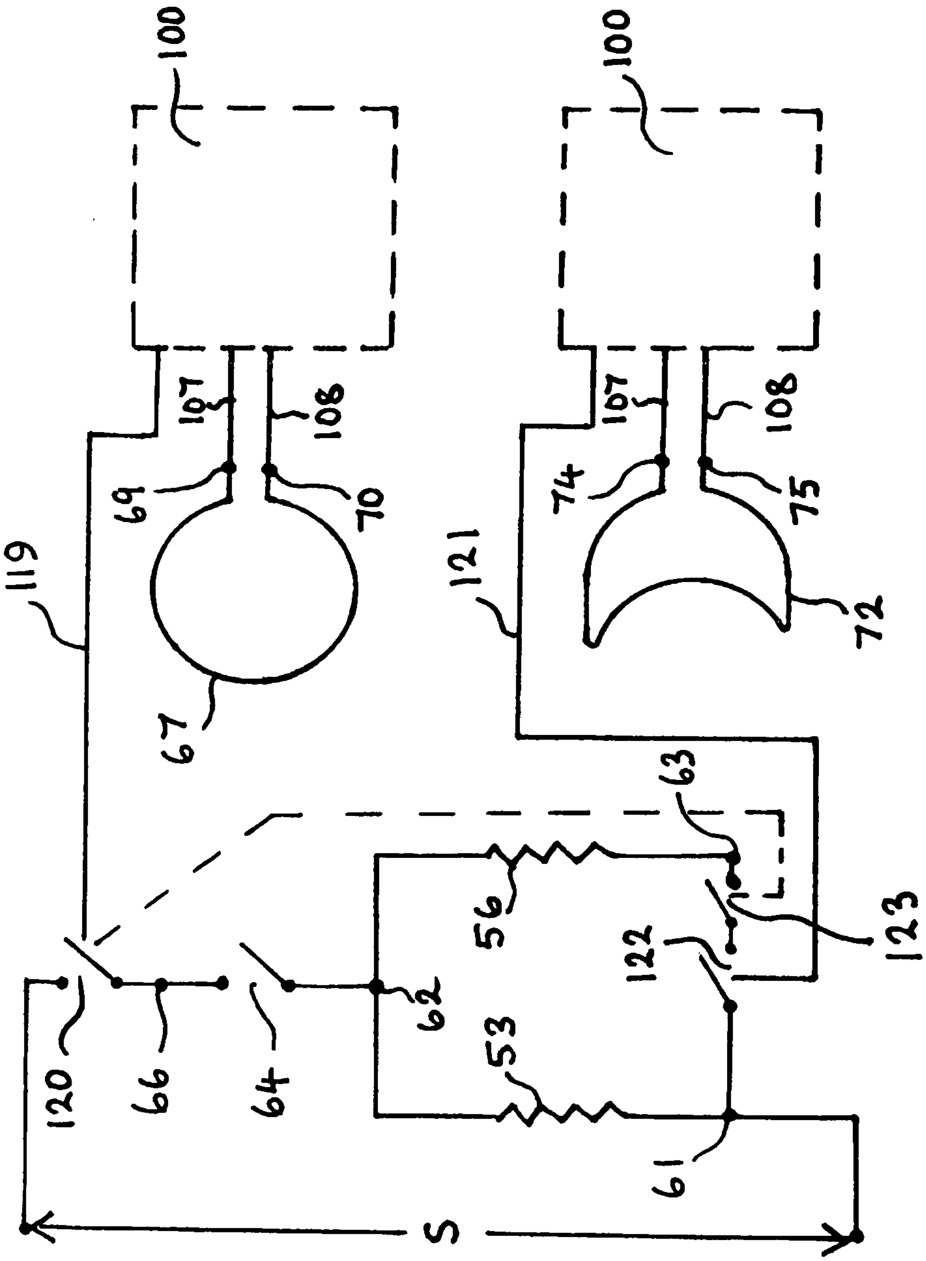
100
100
107
108
107
108
69
70
74
75
119
121
67
72
63
56
123
122
120
66
64
62
53
61
S

FIG. 9

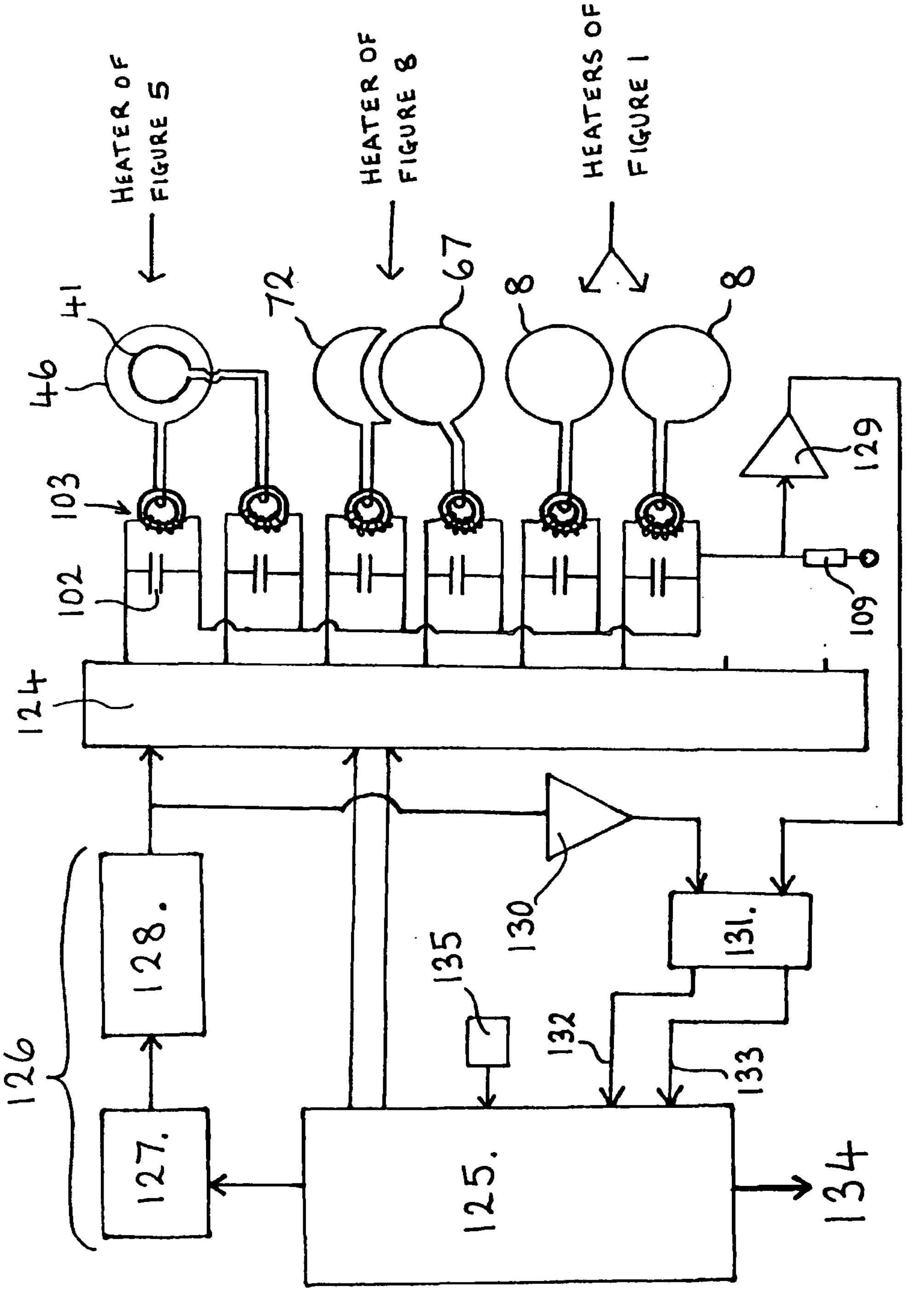
HEATER OF FIGURE 5
HEATER OF FIGURE 8
HEATERS OF FIGURE 1
41
46
72
67
8
8
103
102
129
109
124
126
128.
127.
125.
130
131.
135
132
133
134

FIG. 10